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(71) Applicant: JEMTEX INK JET PRINTING LTD. [IL/IL]; Tevuot Haaretz Street 3, 61241 Tel Aviv (IL).

(72) Inventor: SHEINMAN, Yoshua; Shlonsky Street 21, 43592 Ra'anana (IL).

(74) Agent: A. TALLY EITAN - ZEEV PEARL, D. LATZER & CO.; Law Offices, Lumir House, Maskit Street 22, 46733 Herzelia (IL).

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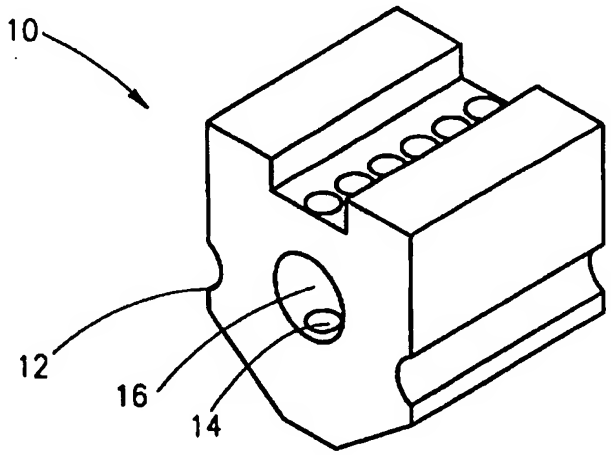
(54) Title: A PRINTING FLUID MULTI-JET GENERATOR AND METHOD FOR PRINTING USING SAME

(57) Abstract

A printing method which includes the steps of providing a stream of a printing fluid, forming a plurality of jets of the printing fluid from the stream, each jet having a predetermined direction, generating printing fluid droplets from each of the jets, the printing fluid droplets having the same predetermined direction. In the preferred embodiment the step of generating includes the step of substantially simultaneously perturbing the pressure of the jets. The method also includes the step of deviating selected ones of the ink droplets from the predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate. According to the present invention, a printing apparatus (400) employing the printing method includes at least one plurality of printing fluid multi-jet generators (10) connected therebetween, each multi-jet generator (10) includes a plurality of channels (14), each of which for generating a printing fluid jet (17) having a predetermined direction therefrom, a printing fluid reservoir (16) connecting the plurality of channels (14) of substantially all the plurality of multi-jet generators (10) for providing a stream (15) of the printing fluid to each of the plurality of channels (14) of the plurality of multi-jet generators (10) whereby the printing fluid jet (17) forms a plurality of printing fluid droplets (19), and a printing fluid droplets deviation unit (306) operative downstream the plurality of multi-jet generators (10) for deviating selected ones of the printing fluid droplets (328) from the predetermined direction, thereby forming a pattern of the printing fluid droplets (332) forming an image (330) on a printing substrate (308).



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A PRINTING FLUID MULTI-JET GENERATOR AND METHOD FOR PRINTING USING SAME

FIELD OF THE INVENTION

The present invention relates to apparatus and method for multi-jet ink generation for ink jet printing heads incorporated in ink jet printers generally and more particularly to apparatus and method for multi-jet ink generation employing pressure perturbation.

BACKGROUND OF THE INVENTION

Ink jet printers employ various physical forces to take small quantities of ink from a reservoir, convert them into droplets, and transport the droplets through the air to the printing medium, such as paper, transparencies, metal, glass etc. The forces used to create and transport the droplets may be mechanical, electrostatic or thermal. Ink jet printers fall into two main categories -- continuous-jet and drop-on-demand.

In both types of devices, droplets are formed by forcing a printing fluid, or ink, through a nozzle. Hence, the ink-jet devices typically include a multitude of very small diameter nozzles. Drop-on-demand systems typically use nozzles having openings ranging from 30 to 100 μm while Hertz continuous-jet systems typically use nozzles having openings ranging from only 10-20 μm.

The use of such nozzles leads to a number of difficulties, not the least of which is the relatively high incidence of nozzle clogging, high cost of manufacture, the requirement for tight tolerances and strict materials limitations. To avoid nozzle clogging and increase the reliability of such printers, high-grade fine filters must be used upstream of the nozzle to avoid dirt particles in the ink from reaching the nozzle. Furthermore, during the time printer is not in use, the ink should not dry in the nozzle since a solid deposit will also result in clogging. To avoid this difficulty a humectant is used in the ink to prevent the ink from drying except when it contacts the paper. The ink must also contain fungicides to prevent biological growth which could result in nozzle clogging by fungi or bacteria. To obtain ink of a required color, a suitable dye must be added to the ink. Color pigments cannot be used since they clog the nozzle or the filter. The choice of dye is critical since the dye must not form a solid deposit with the humectant if the ink is allowed to dry in the nozzle.

All these strict requirements relating to the inks, severely limit the choice of inks which may be used in ink-jet systems using nozzles. Much r search has been devoted to optimizing ink compositions in an attempt to find inks which have suitable characteristics. Typically, an ink found to be suitable represents a number of tradeoffs and compromises with respect to a series of properties.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention is to provide a multi-jet generator for applying printing fluids on a printing substrate.

A further object of the present invention is to provide an improved printing apparatus which includes a plurality of the multi-jet generators of the present invention.

Yet a further object of the present invention is to provide an improved printing system which includes a number of the printing apparatus of the present invention.

According to one aspect of the present invention, the multi-jet generator is constructed so as to operate with a wide variety of ink composition, such as UV-curable pigment containing inks.

According to a further aspect of the present invention, the printing apparatus provides a matrix of streams of printing fluid, each of which converges into a jet of printing fluid which, in turn, is broken into droplets in a controlled fashion. The droplets thus formed can be employed for non-contact printing of a printing substrate.

There is thus provided, in accordance with a preferred embodiment of the present invention, a printing method which includes the steps of:

A. providing a stream of a printing fluid;

B. forming a plurality of jets of the printing fluid from the stream, each jet having a predetermined direction;

C. generating printing fluid droplets from each of the jets, the printing fluid droplets having the same predetermined direction, the step of generating includes the step of substantially simultaneously perturbing the pressure of the jets; and

D. deviating selected ones of the ink droplets from the predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate.

Further, in a preferred embodiment the step of providing includes the step of inputting the printing fluid in a direction generally perpendicular to the predetermined direction. Still further the step of providing may also include the step of inputting the printing fluid into a printing fluid reservoir and wherein the stream being formed from the printing fluid reservoir.

In accordance with a preferred embodiment of the present invention, the step of perturbing includes the step of increasing the pressure, from a generally

constant operation pressure and decreasing the pressure generally to the constant operation pressure and repeating the increasing and decreasing a desired plurality of times.

Preferably, the steps of increasing and decreasing include the step of vibrating the stream of printing fluid. In an alternative preferred embodiment, the steps of increasing and decreasing include the step of shaking the plurality of jets.

In accordance with yet a further preferred embodiment, the method may also include the step of controlling a rate of the step of generating printing fluid droplets by changing the pressure of the jet of printing fluid, the change in pressure in accordance with a change in a frequency of the vibration or the shaking.

Further, the step of deviating includes the steps of charging selected ones of the printing fluid droplet not included in the pattern, and deflecting the charged printing fluid droplets from the predetermined direction.

There is also provided in accordance with the present a printing fluid channel which includes an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between the narrowed section and the aperture for generating a jet of printing fluid from the stream of printing fluid. In a preferred embodiment, the aperture is substantially smaller than the narrowed section.

In accordance with a preferred embodiment of the present invention, the chamber is generally cylindrical in shape and the outlet section is generally conical in shape and the narrowed section is generally shaped as an O-ring.

There is also provided, in accordance with a preferred embodiment of the present invention a printing fluid multi-jet generator which includes a printing fluid reservoir for providing a stream of printing fluid and a plurality of the channels of the present invention.

In a preferred embodiment, the printing fluid reservoir and the plurality of channels are generally perpendicular and the distance between adjacent ones of the plurality of channels is substantially similar.

Further, according to the present invention, the multi-jet generator may also include a vibration unit for vibrating the multi-jet generator, thereby perturbing the pressure in the plurality of channels, whereby breakage of the printing fluid jets into printing fluid droplets is induced. In a preferred embodiment, the vibration

unit includes a piezoel ctric transducer external to the printing fluid reservoir and operative to vibrate a pedal within the printing fluid reservoir.

There is also provided, in accordance with yet a further preferred embodiment of the present invention, a printing apparatus which includes at least one plurality of the printing fluid multi-jet generators of the present invention connected therebetween,

a printing fluid reservoir connecting the plurality of channels of substantially all the plurality of multi-jet generators for providing a stream of the printing fluid to each of the plurality of channels, a vibration unit for generating a pressure perturbation in each of the plurality of channels of the plurality of multi-jet generators whereby the printing fluid jet forms a plurality of printing fluid droplets, and a printing fluid droplets deviation unit operative downstream the plurality of multi-jet generators for deviating selected ones of the printing fluid droplets from the predetermined direction, thereby forming a pattern of the printing fluid droplets forming an image on a printing substrate.

In a preferred embodiment, the vibration unit is operative to vibrate the printing apparatus, thereby shaking the printing fluid, wherein the shaking generates the pressure perturbation. Accordingly, the vibration unit includes a first plate connected to the at least one plurality of multi-jet generators, a second plate, a plurality of mountings disposed intermediate the first plate and the second plate, and a piezoelectric transducer also disposed intermediate the first plate and the second plate, wherein the natural frequency of the plurality of mountings is smaller than that of the piezoelectric transducer.

Alternatively, the vibration unit is an external piezoelectric transducer operative to vibrate the printing fluid in the printing fluid reservoir or a piezoelectric transducer external to the printing fluid reservoir and operative to vibrate a pedal within the printing fluid reservoir.

Finally, according to the present invention the droplets deviation unit includes a charging unit for charging selected ones of the printing fluid droplet not included in the pattern and a deflection unit for deflecting the charged printing fluid droplets from the predetermined direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The pres nt invention will be understood and appreciated more fully from the following detailed description taken in conjunction with the appended drawings in which:

Fig. 1A is a schematic isometric illustration of a multi-jet generator, constructed and operative in accordance with a first embodiment of the present invention;

Fig. 1B is a schematic cross section illustration through one of the channels of the multi-jet generator of Fig. 1A;

Fig. 2 is a schematic isometric illustration of a multi-jet printing apparatus; constructed and operative in accordance with a preferred embodiment of the present invention;

Fig. 3 illustrates the printing apparatus of Fig. 2 with an external vibration unit;

Fig. 4A is a schematic cross section illustration through one of the channels of the multi-jet generator of Fig. 1A with an internal vibration unit;

Figs. 4B and 4C are schematic isometric illustrations of a printing unit of the printing apparatus of Fig. 2 with an external vibration unit and an external vibration unit for each multi-jet generator, respectively;

Fig. 5A is a schematic cross section illustration of the selective charging and deflection unit of a printing unit of the printing apparatus of Fig. 2;

Figs. 5B and 5C are detailed schematic cross section illustrations of the two embodiments of the selective charging and deflection unit of Fig. 5A;

Fig. 6 is a schematic block diagram illustration of the printing method of the present invention; and

Fig. 7 is a schematic cross section illustration of a printing system which includes a plurality of the multi-jet printing apparatus of Fig. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made to Figs. 1A through 1C which illustrate a multi-jet generator, generally referenced **10**, constructed and operative according to a preferred embodiment of the present invention. Multi-jet generator **10** provides streams of printing fluid which converge into jets of printing fluid which, in turn, are broken up into droplets which are selectively charged and deflected downstream from generator **10**. The term "stream of printing fluid", hereinafter also "stream", refers throughout the specification and claims to a two-dimensional flow of printing fluid and the term "jet of printing fluid", hereinafter also "jet", refers throughout the specification and claims to a uni-directional flow of printing fluid.

Multi-jet generator **10** comprises a member **12** having a plurality of channels **14** formed therethrough and a printing fluid reservoir **16** which connects the plurality of channels therebetween. In the illustrated embodiment, printing fluid reservoir **16** is generally perpendicular to channels **14**. As best seen in Fig. 1B., each channel **14** provides a single vertical stream **15** which converges into a vertical jet **17** from which printing fluid droplets **19** are formed. In the illustrated embodiment, channels **14** are spaced in generally equal distances one from the other so as to provide ink droplets **19** in a predetermined resolution.

Each channel **14** comprises an inlet section **18** adjacent and in connection with printing fluid reservoir **16**, an outlet section **20** and a printing fluid stream chamber **22** disposed therebetween.

In a preferred embodiment, channels **14** are produced by forming a hollow through member **12** and using a cap **21** to close each of channels **14** above printing fluid reservoir **16**.

In the illustrated embodiment, chamber **22** is cylindrical in shape and outlet section **20** is conical in shape with an aperture at its end. Thus the dimension, i.e. the diameter of chamber **22** is generally similar therealong and is larger than the decreasing diameter of outlet **20**. Preferably, a narrowing device **24** is disposed in the entrance into chamber **22**, the narrowed section increases the velocity of stream **15** downstream therefrom, i.e. in chamber **22**. In the illustrated embodiment, narrowing device **24** is shaped as an O-ring and supported by protrusion **26**. In the preferred embodiment, the aperture at the end of outlet **20** is substantially smaller than that of the narrowed section formed by narrowing device **24**.

It will be appreciated that each multi-jet generator **10** is connectable to any numb r of other multi-jet generators so as to form a printing apparatus as shown in Fig. 2 to which reference is now made.

Fig. 2 illustrates a printing apparatus, generally referenced **100**, which comprises at least one plurality of multi-jet generators **10** connected therebetween. In the illustrated embodiment, printing apparatus **100** comprises three pluralities of multi-jet generators **10**, individually referenced **102A**, **102B** and **102N**, and collectively termed hereinafter printing units **102**. It will be appreciated that three printing units are shown as a non limiting example.

As illustrated for printing unit **102A**, each printing unit comprises a plurality of multi-jet generators **10** connected therebetween and forming a single reservoir for the entire unit, generally referenced **116**. As best seen for printing unit **102N**, multi-jet generators **10** may be connected via connectors **104** to form the single reservoir **116**.

Printing apparatus **100** further comprises a vibration unit described in detail with reference to Figs. 3 through 4C hereinbelow for vibrating printing units **102** separately or collectively, thereby generating a pressure perturbation in the printing unit for whereby the printing fluid jet forms a plurality of printing fluid droplets and a printing fluid droplets deviation unit **106** operative downstream the plurality of multi-jet generators **10** for deviating selected ones of the printing fluid droplets from their predetermined direction, thereby forming a pattern of the printing fluid droplets forming an image on a printing substrate as described in detail with reference to Figs. 5A through 5C hereinbelow.

Referring now to Fig. 3, printing apparatus **100** is illustrated with a vibration unit **110**. Vibration unit **110** comprises a first plate **112**, connected to printing units **102A**, **102B** and **102N**, a second plate **114**, spaced away from plate **112** and connected to an external support (not shown), a vibration device **118** and mountings **120**. In a preferred embodiment, vibration device **118** is a piezoelectric transducer and mountings **120** are relatively soft mountings having self vibration frequency which is lower, and preferably substantially lower than the vibration frequency of the piezoelectric transducer.

In operation, printing units **102** have a constant operation pressure. Then, vibration device **118** vibrates as indicated by arrows **122**, the vibration shakes the printing units **102** so as to collectively increase the pressure in channels **14**. The increase in pressure induces breakage of jet **17** into droplets **19**

which a portion representing an image to be printed is subsequently applied to printing substrate **130**.

It will be appreciated that the size of the generated printing fluid droplets depend on their physicochemical properties (e.g. viscosity) on their velocity absent additional pressure and on the frequency of vibration of vibrating device **118**, therefore the size of droplets **19** may be controlled by changing the frequency of vibration of vibration device **118**.

It will also be appreciated that vibration device **118** vibrates printing apparatus **100** and not the fluid therein. Alternatively, the fluid itself can be vibrated as shown in Fig. 4A to which reference is now made. In the embodiment of Fig. 4A, a piezoelectric transducer **126** is connected to a pedal **128** disposed intermediate reservoir **16** so as to induce vibration therein as indicated by arrow **129** substantially simultaneously in all channels **14**, thereby inducing the breakage of jets **17** into droplets **19** in all the channels.

In yet another preferred embodiment, the fluid stream to each printing unit is being vibrated so as to increase the pressure in reservoir **116** and channels **14** so as to induce breakage of jets **17** into droplets **19** substantially simultaneously in all channels. In the embodiment illustrated in Fig. 4B, an external vibration unit **138** vibrates by any suitable means, such as a piezoelectric transducer, in the direction indicated by arrows **140**. This lateral vibration effects the pressure in reservoir **116** (Fig. 2) as described hereinabove. In the embodiment of Fig. 4C, each multi-jet generator **10** includes a vibration devices **148** which is operative to induce the added pressure for inducing breakage of jets **17** into droplets **19** substantially simultaneously for all channels.

Reference is now made to Figs. 5A - 5C which illustrate deviation unit **106** and its operation. Deviation unit **106** comprises a charging unit **202** and a deflection unit **204**.

Charging unit **202** is operative to selectively charge printing fluid droplets which are not to be applied on printing substrate **130** wherein deflection unit **204** is operative to deflect the charged droplets to a collection system (not shown). In the illustrated embodiment, printing droplets deviation units **106** are disposed on opposite sides of the printing droplets formed by each printing units **102** (Fig. 2), thus each unit **106** is operative on two printing fluids droplets as described hereinbelow.

Each charging unit **202** comprises two electrodes, a positively charged electrode, referenced **212** or **232**, and a negatively charged electrode **222**. As

illustrated in Fig. 5A, the electrodes are arranged so that the positively charged electrode **212** on one unit **202** faces the negatively charged electrode **222** of its adjacent electrode.

Unit **202** may also include an illumination source **206**, such as a Light Emitting Diode (LED) source and a detection unit **208**, such as a diode, for detecting light reflected by droplet **230**.

In one preferred embodiment, shown in the left and right units **202** and in greater details in Fig. 5B, illumination source **206** and detector **208** form a single unit and the positively charged electrode is formed as a wire **232** common to all channels of the printing unit. Alternatively, as shown in the center unit **202** (Fig. 5A) and in greater detail in Fig. 5C, illumination source **206**, detector **208** and positively charged electrode **212** are separate.

In operation, once a first droplet **230** crosses the illumination beam of LED **206** the light is reflected therefrom and is detected by detector **208** so as to set a timing for each droplet which is used to control the operation of electrodes **212** and **222** in an information wise manner. Alternatively, illumination device **206** and detection device **208** are on opposite sides of the jet, in which case detector **208** detects the light absorbed by droplet **230**.

Preferably, illumination source **206** is operative to illuminate the printing droplets with a color insensitive radiation, such as an Infra Red radiation of suitable wavelength so that the system will not depend on the color of the printing droplet.

The operation of multi-jet generator **10** and each printing unit **102** of printing apparatus **100** is now described with reference also to Fig. 6. The method preferably includes three major steps, the step of forming a jet of a printing fluid in a predetermined direction which take place in each channel **14** (step 302), the step of generating ink droplets from the jet of printing fluid in the same predetermined direction which takes place in the open air as indicated by **304** and the step of deviating selected ones of the ink droplets from the predetermined direction which takes place in the ink droplets deviation unit as indicated by **306** and the printing step in which a pattern of ink droplets forming an image to be printed on a printing substrate to be printed as indicated by **308**.

The step of generating a printing jet comprises the step of forming a printing stream **310** which is converted in the open air to a unidirectional printing jet. In a preferred embodiment, a printing fluid inflow is inputted (step 312) into the

printing fluid reservoir **16** (Fig. 1B) or **116** (Fig. 2) as indicated by block **314**, the output from which forms the stream of printing fluid as indicated by block **316**.

According to a preferred embodiment of the present invention, the printing fluid in reservoir is perturbed as described in detail with reference to Figs. 3 through 4C hereinabove so as to control the rate of ink droplets generation from the printing jet.

According to the pressure perturbation, the printing jet travels as indicated by step 318 in a preferred predetermined direction, preferably downwards as indicated by arrow **320** so as to form ink droplets **322** having same predetermined direction.

In order to effect printing, the ink droplets are selectively being charged (step 324) while traveling in the predetermined direction **320** for subsequent selective deflection thereof (step 326) as described in detail with reference to Figs. 5A through 5C hereinabove so as to deviate the ink droplets which do not form part of the printed image as indicated by arrow **328**.

The droplets not being deflected at **326** impinge the printed substrate, thereby forming the printed image as indicated by **330** and arrow **332**.

Reference is now made to Figure 7, which illustrates a printing system, generally referenced **400**, which comprises a printing apparatus **100** for each color to be printed. In the illustrated embodiment, printing system **400** is a four color process colors, Cyan, Magenta, Yellow and Black (CMYK or CMYB) printing system which correspondingly comprises a printing apparatus **100C**, **100M**, **100Y** and **100K** for printing the CMYK colors, respectively. Typically each multi-jet generator **10** can provide 50 dots per inch (dpi) and therefore each color head, for example, color head **100C**, includes four staggered printing units **102** to effect high resolution single-pass color printing of 200 dpi. Between each printing apparatus **100C, 100M, 100Y** and **100K**, the printing medium may be treated in some desirable fashion. For example, when UV-curable ink is used, an UV lamp **103** may be located following each printing unit **102** in order to fix the most recently used color.

Printing system **400** can be used to print, mark and/or plot on various printing substrates, including paper, glass, plastic, metal and fabric. Printing system **400** is particularly suitable for large format printing by virtue of the static nature of the multi-jet generators 10. Any suitable method of creating a variety of different colors can be used. One such scheme involves placing dots of different colors in the immediate vicinity of dots of different colors so as to form the visual

perception in the mind of the viewer of a new color, much the way this is accomplished in half toning techniques.

All in all, printing system **400** integrating multi-jet generator devices of the present invention offers a number of advantages over conventional continuous ink jet technology. First, the multi-jet generator device according to the present invention includes few moving parts, is inherently reliable and trouble free, and is less expensive to build than conventional devices which require a multitude of precision-made nozzles. Second, the multi-jet generator device features little or no interaction between adjoining jets. And third, the multi-jet generator device is able to use a greatly enlarged group of printing fluids, including photo-polymers (such as UV-curable ink) which are shear-sensitive and cannot normally be passed through small diameter nozzles without polymerizing or otherwise degrading. Furthermore, feed of printing fluids is considerably simplified.

It will be appreciated that the preferred embodiments described hereinabove are described by way of example only and that numerous modifications thereto, all of which fall within the scope of the present invention, exist.

It will also be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described herein above. Rather the scope of the invention is defined by the claims which follow:

CLAIMS

1. A printing method comprising the steps of:
   a. providing a stream of a printing fluid;
   b. forming a plurality of jets of said printing fluid from said stream, each jet having a predetermined direction;
   c. generating printing fluid droplets from each of said jets, said printing fluid droplets having said same predetermined direction, said generating comprising the step of substantially simultaneously perturbing the pressure of said jets; and
   d. deviating selected ones of said ink droplets from said predetermined direction, thereby forming a pattern of ink droplets forming an image on a printing substrate.
2. A method according to claim 1 wherein said providing comprises inputting said printing fluid in a direction generally perpendicular to said predetermined direction.
3. A method according to claim 1 wherein said providing comprises inputting said printing fluid into a printing fluid reservoir and wherein said stream being formed from said printing fluid reservoir.
4. A method according to claim 1 wherein said perturbing comprises increasing said pressure, from a generally constant operation pressure and decreasing said pressure generally to said constant operation pressure and repeating said increasing and decreasing a desired plurality of times.
5. A method according to claim 4 wherein said increasing and decreasing comprises vibrating said stream of printing fluid.
6. A method according to claim 4 wherein said increasing and decreasing comprises shaking said plurality of jets.
7. A method according to any of claims 5 or 6 further comprising the step of controlling a rate of said generating printing fluid droplets by changing said pressure of said jet of printing fluid, said change in pressure in accordance with a change in a frequency of said vibration.

8. A method according to claim 1 wher in said step of deviating comprises:

   a. charging selected ones of said printing fluid droplet not included in said pattern; and

   b. deflecting said charged printing fluid droplets from said predetermined direction.

9. A printing fluid channel comprising:

   a. an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom;

   b. an outlet section having an aperture; and

   c. a chamber disposed between said narrowed section and said tip for generating a jet of printing fluid from said stream of printing fluid.

10. A printing fluid channel according to claim 9 wherein said chamber is generally cylindrical in shape and said outlet section is generally conical in shape.

11. A printing fluid channel according to any of claims 9 - 10 wherein said narrowed section is generally shaped as an O-ring.

12. A printing fluid multi-jet generator comprising:

   a. a printing fluid reservoir for providing a stream of printing fluid;

   b. a plurality of channels, each channel comprising an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between said narrowed section and said aperture for generating a jet of printing fluid from said stream.

13. A multi-jet generator according to claim 12 wherein said printing fluid reservoir and said plurality of channels are generally perpendicular.

14. A multi-jet generator according to claim 12 wherein the distance between adjacent ones of said plurality of channels is substantially similar.

15. A multi-jet generator according to claim 12 wherein said narrowed section is a narrowing device.

16. A multi-jet generator according to claim 15 wherein said narrowing device is generally shaped as an O-ring.

17. A multi-jet generator according to claim 12 wherein said chamber is generally cylindrical in shape and said outlet section is generally conical shape.

18. A multi-jet generator according to any of claims 12 - 17 and also comprising a vibration unit for vibrating said multi-jet generator, thereby perturbing the pressure in said plurality of channels, whereby breakage of said printing fluid jets into printing fluid droplets is induced.

19. A multi-jet generator according to claim 18 wherein said vibration unit comprises a piezoelectric transducer external to said printing fluid reservoir and operative to vibrate a pedal within said printing fluid reservoir.

20. A printing apparatus comprising:

a. at least one plurality of printing fluid multi-jet generators connected therebetween, each multi-jet generator comprising a plurality of channels, each of which for generating a printing fluid jet having a predetermined direction therefrom;

b. a printing fluid reservoir connecting the plurality of channels of substantially all said plurality of multi-jet generators for providing a stream of said printing fluid to each of said plurality of channels;

c. a vibration unit for generating a pressure perturbation in each of said plurality of channels of said plurality of multi-jet generators whereby said printing fluid jet forms a plurality of printing fluid droplets; and

d. a printing fluid droplets deviation unit operative downstream said plurality of multi-jet generators for deviating selected ones of said printing fluid droplets from said predetermined direction,

thereby forming a pattern of said printing fluid droplets forming an image on a printing substrate.

21. A printing apparatus according to claim 20 wherein each said channel comprises an inlet section having a narrowed section in an outlet end thereof for increasing stream velocity downstream therefrom, an outlet section having an aperture, and a chamber disposed between said narrowed section and said aperture for generating a jet of printing fluid from said stream of printing fluid.

22. A printing apparatus according to claim 20 wherein said printing fluid reservoir and said plurality of channels are generally perpendicular.

23. A printing apparatus according to claim 20 wherein said vibration unit is operative to vibrate said printing apparatus, thereby shaking said printing fluid, wherein said shaking generates said pressure perturbation.

24. A printing apparatus according to claim 23 wherein said vibration unit comprises:

a. a first plate connected to said at least one plurality of multi-jet generators:

b. a second plate;

c. a plurality of mountings disposed intermediate said first plate and said second plate; and

d. a piezoelectric transducer also disposed intermediate said first plate and said second plate,

wherein the natural frequency of said plurality of mountings is smaller than that of said piezoelectric transducer.

25. A printing apparatus according to claim 20 wherein said vibration unit is an external piezoelectric transducer operative to vibrate said printing fluid in said printing fluid reservoir.

26. A printing apparatus according to claim 20 wherein said vibration unit comprises a piezoelectric transducer external to said printing fluid reservoir and operative to vibrate a pedal within said printing fluid reservoir.

27. A printing apparatus according to claim 20 wherein said droplets deviation unit comprises:

    a. a charging unit for charging selected ones of said printing fluid droplet not included in said pattern; and

    b. a deflection unit for deflecting said charged printing fluid droplets from said predetermined direction.

28. A printing fluid channel according to claim 9 wherein said aperture is substantially smaller than said narrowed section.

29. A printing fluid multi-jet generator according to claim 12 wherein said aperture is substantially smaller than said narrowed section.

30. A printing apparatus according to claim 21 wherein said aperture is substantially smaller than said narrowed section.

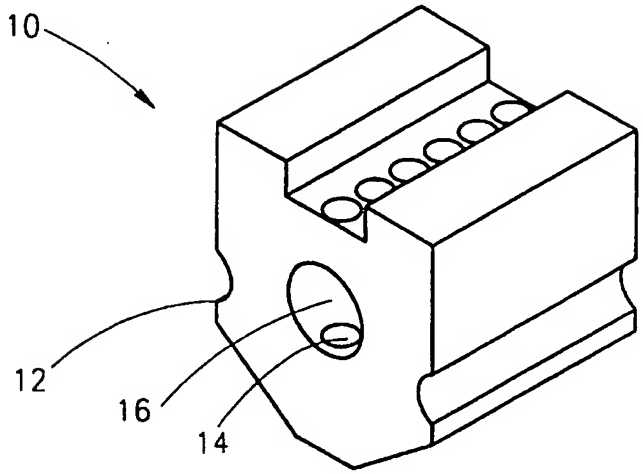


FIG.1A

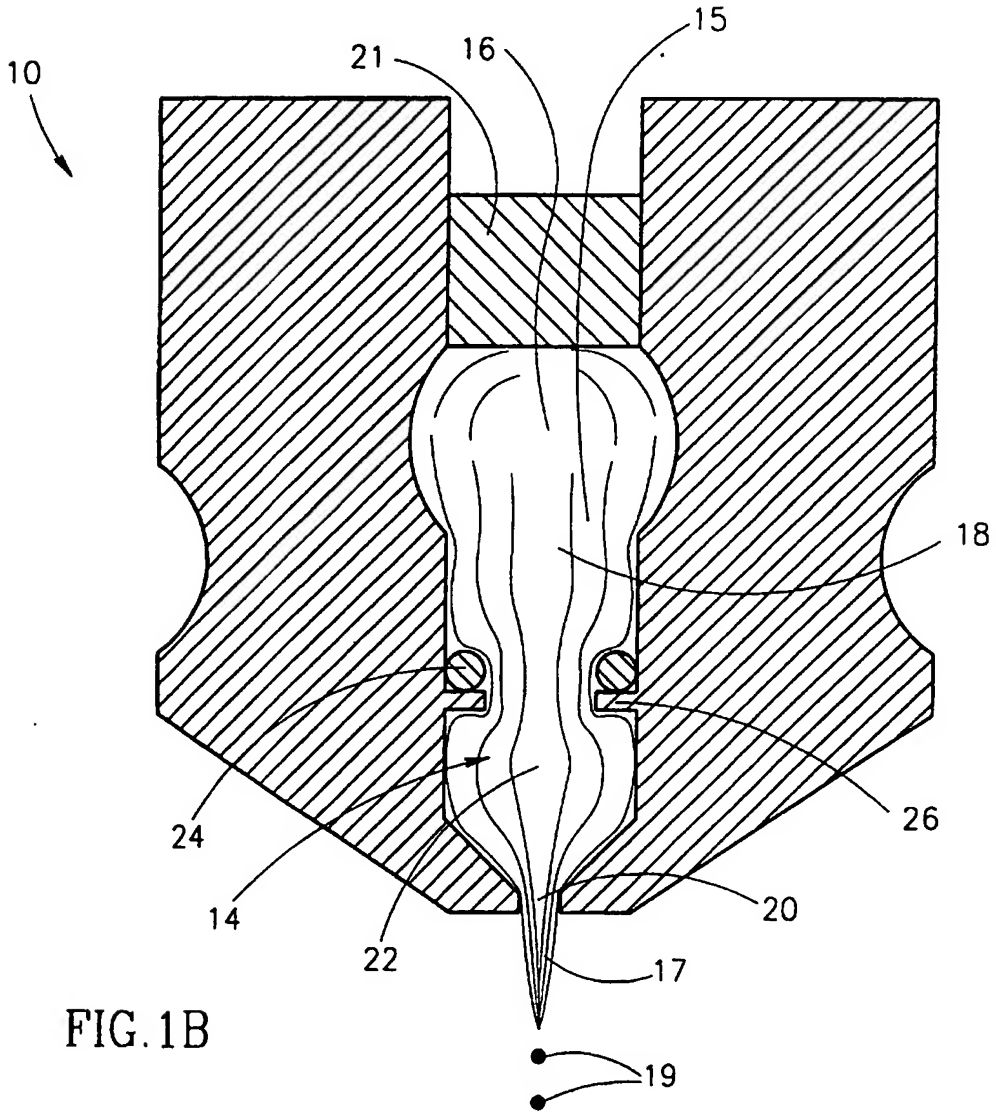


FIG.1B

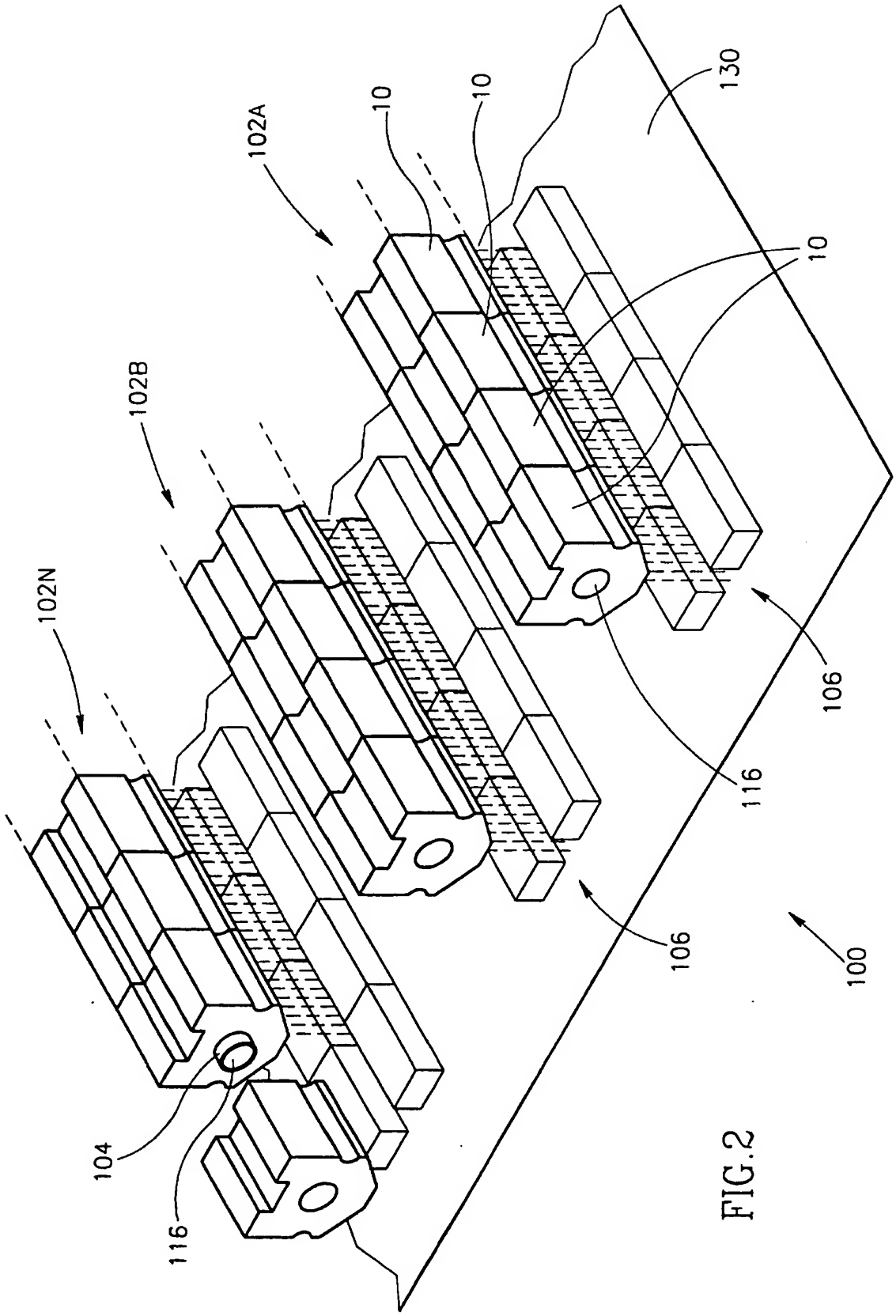


FIG.2

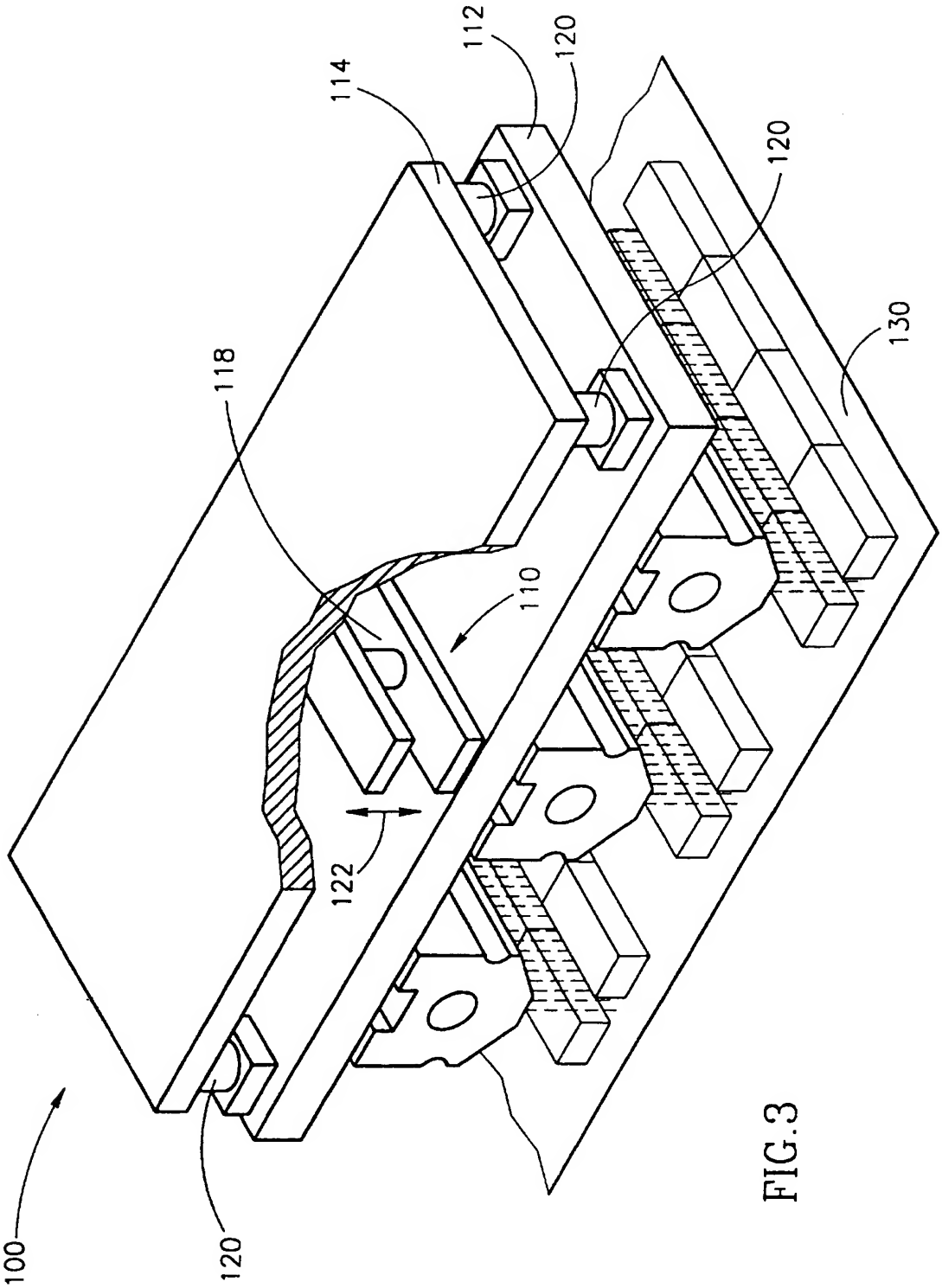


FIG.3

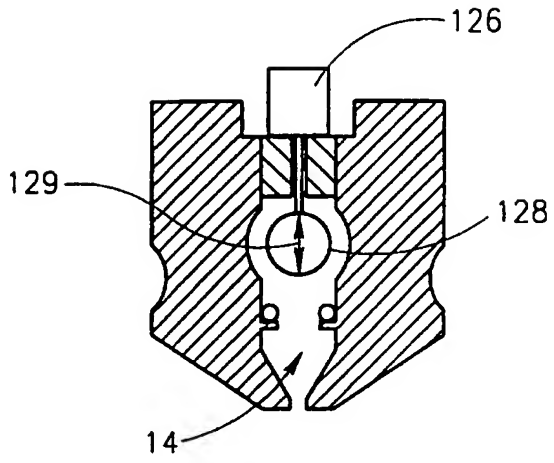


FIG.4A

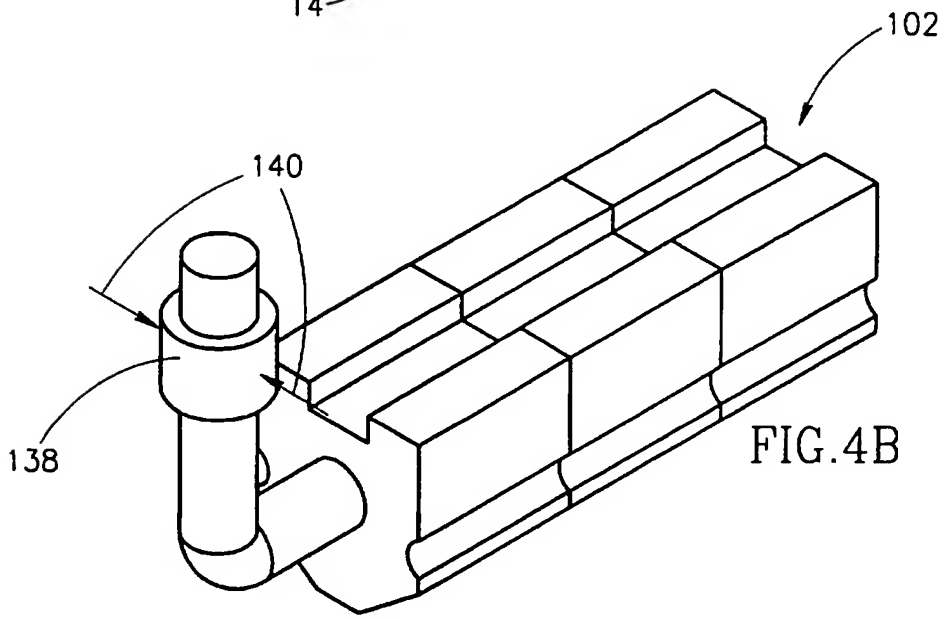


FIG.4B

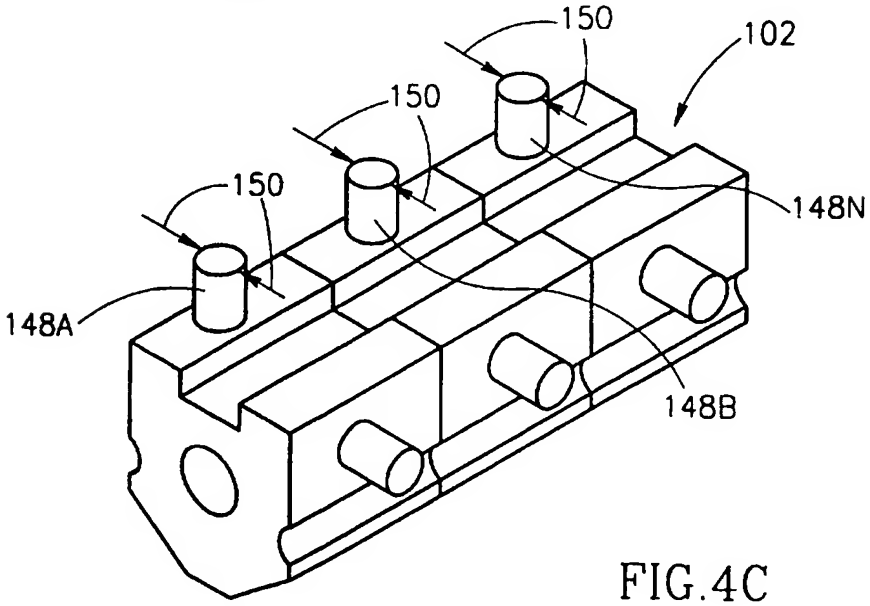


FIG.4C

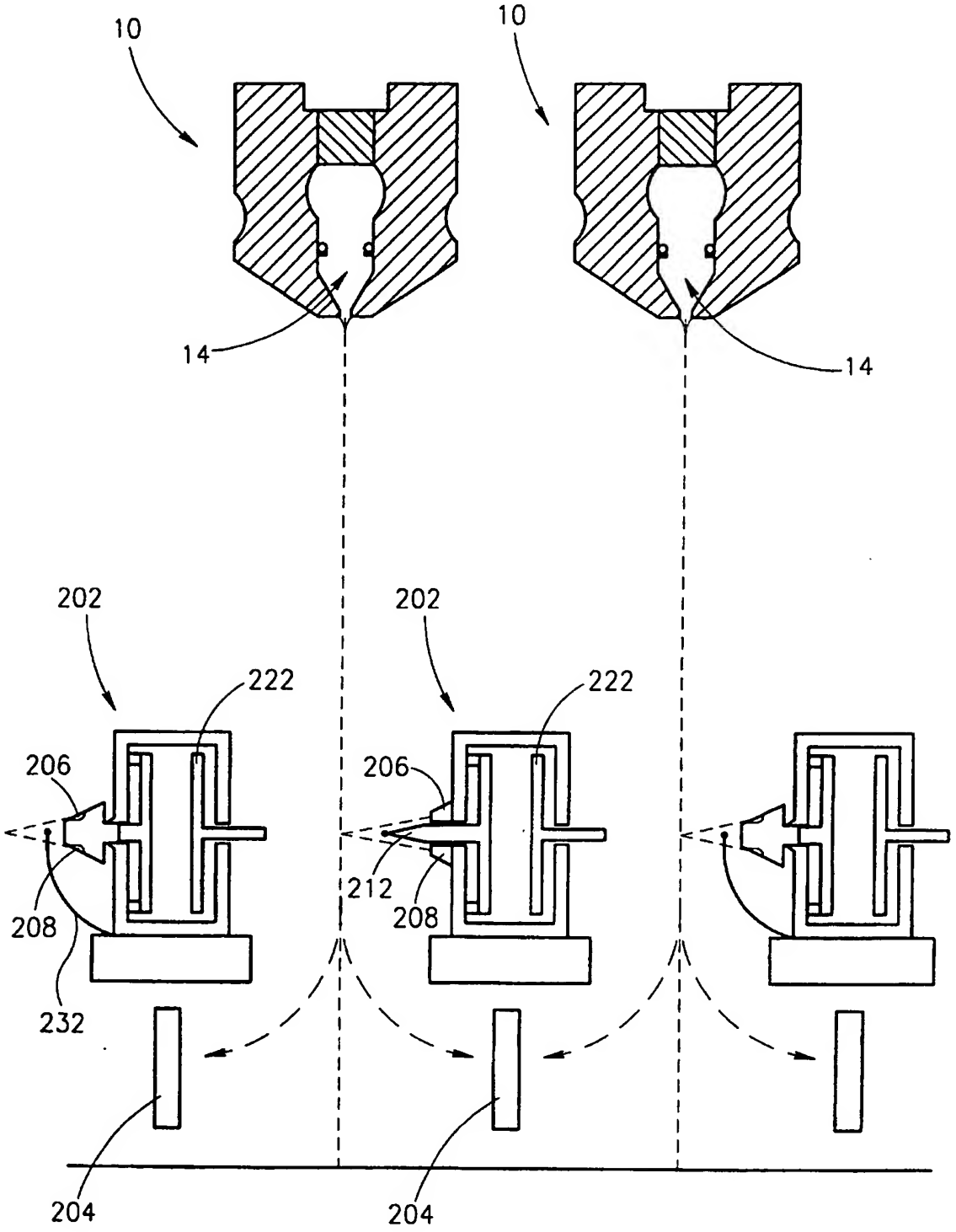


FIG.5A

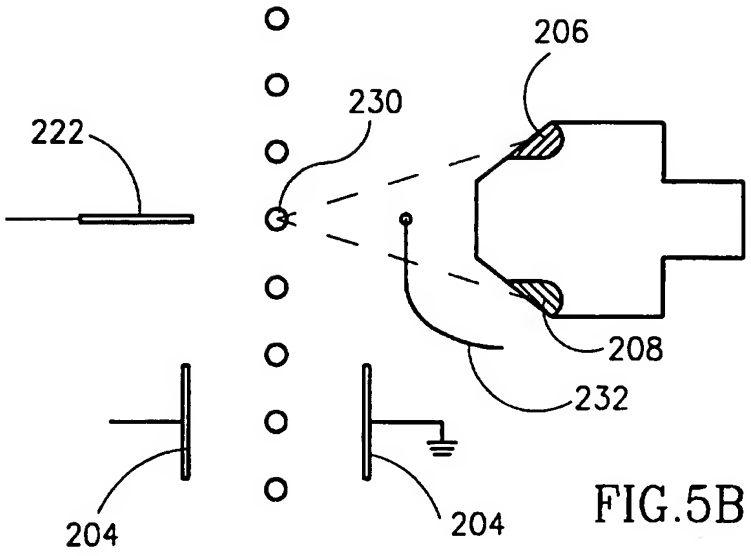


FIG.5B

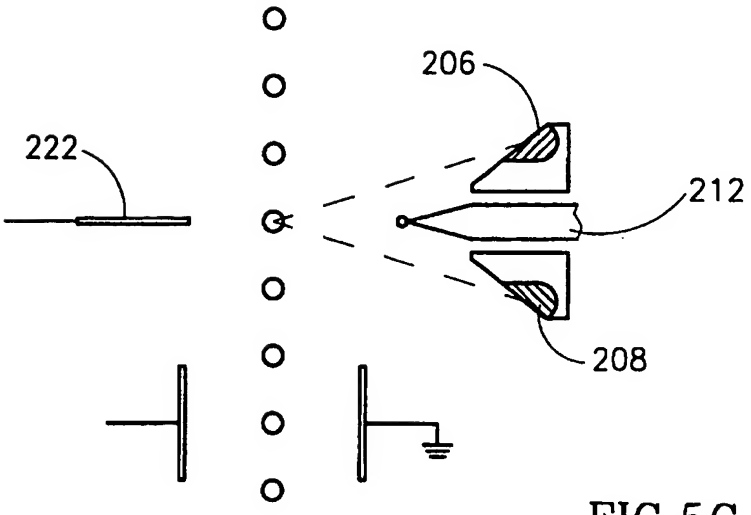
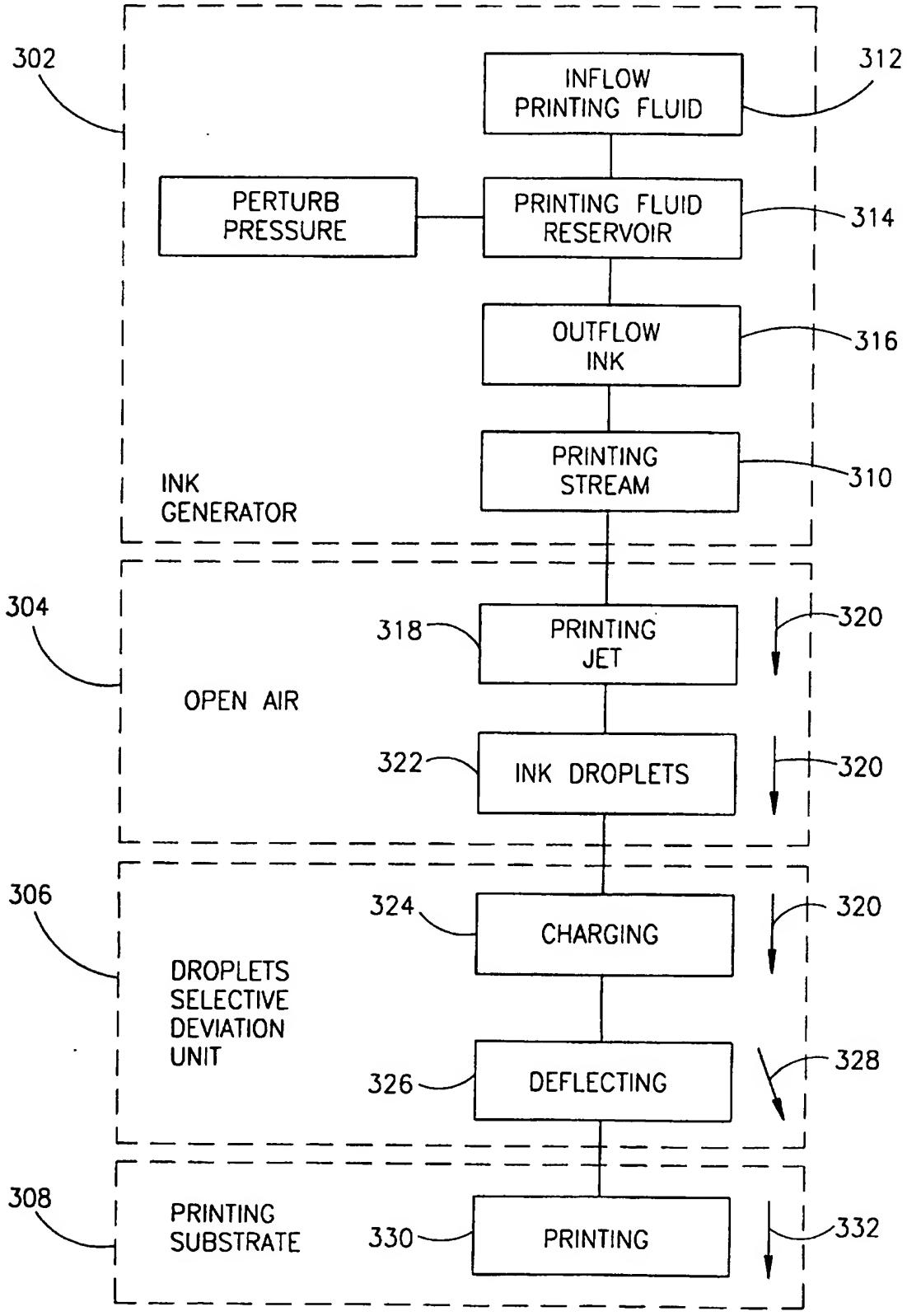


FIG.5C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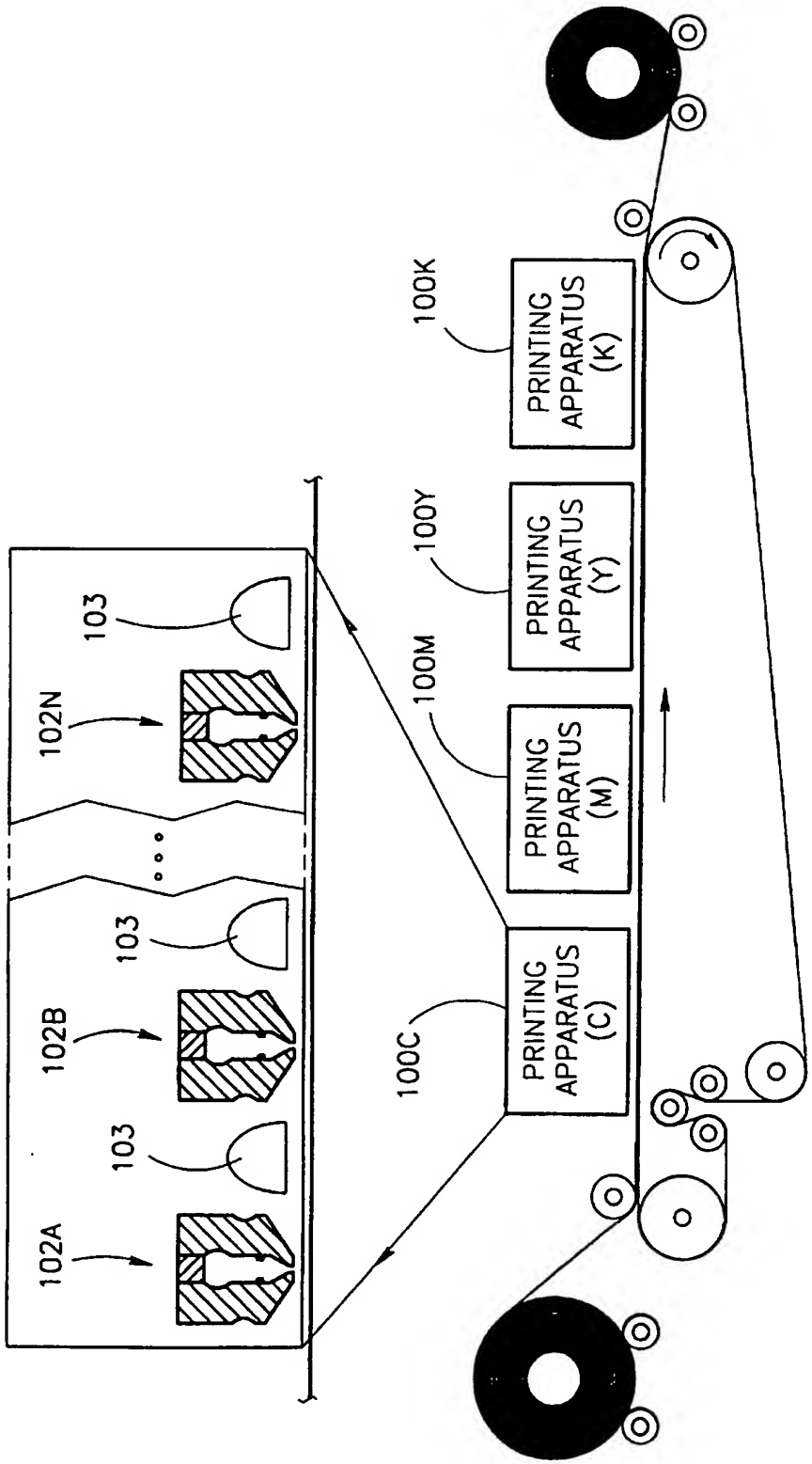
314
OUTFLOW INK
316
PRINTING STREAM
310
INK GENERATOR
304
318
PRINTING JET
320
OPEN AIR
322
INK DROPLETS
320
306
324
CHARGING
320
DROPLETS SELECTIVE DEVIATION UNIT
326
DEFLECTING
328
308
PRINTING SUBSTRATE
330
PRINTING
332

FIG.6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100M
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100C
PRINTING APPARATUS (C)
102A
102B
102N
103
103
103

FIG.7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL97/00139

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B41J 2/02, 2/07, 2/045, 2/085, 2/14, 2/16
US CL : 347/72, 73, 74, 75, 76, 47, 48, 49
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 347/72, 73, 74, 75, 76, 47, 48, 49

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

N/A

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---- Y	US 5,165,061 A (WITTEVEEN) 17 November 1992, See entire document.	10, 13-15, 29-30 ---------- 1-8, 11-12, 16-28
X --- Y	US 4,384,295 A (LEWIS et al.) 17 May 1983, See column 3, lines 12-29; column 4, lines 26-36, 41-49.	9 --- 1-6, 19-28, 31
Y	US 4,085,408 A (MUTO et al.) 18 April 1978, See column 10, lines 1-63; figures 6-8, 10, 12, 17.	7-8

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the international search report
14 JULY 1997	15 AUG 1997
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer THIEN TRAN Telephone No. (703) 308-0080

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL97/00139

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,245,225 A (FILLMORE et al.) 13 January 1981, See figures 2-3	11, 18
Y	US 5,604,523 A (TSUKUDA et al.) 18 February 1997, See column 6, lines 28-30; figure 7B.	12, 16-17